Using Natural ^{210}Pb and its Daughters (^{210}Bi and ^{210}Po) to Estimate Aerosol Residence Times

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Summary

Natural radionuclides have been proposed for use in assessing the transport of ozone and aerosols in the troposphere (*1-2*). Radon daughters can also be used to determine apparent residence times for submicron aerosols in the troposphere by looking at the disequilibrium of ^{210}Pb with its daughters ^{210}Bi (5-day half-life) and ^{210}Po (138-day half-life) (*3-4*). Past work has used a cascade impactor was used to collect samples for these analyses. The result of that worked indicated that submicron analyses were needed to avoid wind blown soil contamination and long apparent lifetimes. Using Sierra impactors and the number 4 plate for a submicron cut-off (aim particle size cut-off, D_{50} between 0.95 µm at a 40 ft^3 min^{-1} flowrate and 1.10 µm at a 30 ft^3 min^{-1} flow rate). Samples were collected at two sites to examine the apparent residence times using this method. The first site was located approximately 5 km east of downtown Pittsburgh on a building roof top adjacent to Schenley Park (40.4395^o N latitude and 79.9405^o W longitude, at an altitude of approximately 310 m . At this site the wind was predominantly from the south and the west. The second site was located at the U.S. Department of Energy National Energy Technology Ambient Air Monitoring Station. This site is approximately 15 km south of downtown Pittsburgh (40.30655^o N latitude and 79.9794^o W longitude, at an elevation of 325 m above sea level. The wind at this site is predominantly from the south and southwest. At both sites, 24 hour samples were collected from July 22 to July 30, 2001. on quartz and cellulose filters. Nine samples were taken at the NETL site and six were taken at the Schenley Park site. Sample volumes ranged from 1320-1600 m^3 of air.

The method for determining the 210Pb and its daughters will be briefly described (*3-4*). The apparent residence times for the samples ranged from 10-46 days with an average of 23 days during this study. The lifetimes are somewhat shorter than seen in other areas of the country. These results will be presented and compared to past results from Mexico City, Argonne National Laboratory, Phoenix, and Centerton, NJ. The results from this work and from past studies (*3-4*) indicate that a substantial amount of the background aerosol entered the areas studied through long-range transport. Typical lifetimes are on the order of 5-40 days for size fractions below 1 µm, for a wide range of sites that we have sampled. These fractions are likely to be associated with carbonaceous aerosols that are not rapidly wet or dry deposited, as sulfate and nitrate aerosols are. This aerosol component probably contributes to the fine submicron aerosol number,

with a less significant addition to the PM-2.5 micron mass. Recent studies on arctic haze have found similar lifetimes of 0-39 days for aerosol samples that were not size fractionated (5).

Past results (1) had indicated 10 day lifetimes for aerosols being removed by wet deposition in good agreement with the current understanding of the washout cycles in the atmosphere. The remaining interstitial aerosol would then be expected to have a longer apparent lifetime. It is likely be composed of carbonaceous soots and other organic containing aerosol components that require some surface oxidation before they can be wetted and be removed by growth, and undergo subsequent wet deposition and/or gravitational settling and removal. Water soluble aerosols such as the sulfates , in particular, will be removed more readily leading to apparently shorter residence times. The results from Pittsburgh may indicate the sulfate removal process is occurring leading to the slightly shorter lifetimes than observed in other sites previously, These results indicate that the background fine aerosol (sub-micron) will still have significant contribution from long range transport and that should be considered when determining control strategies for this important health related material.

References

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